

STUDY GUIDE

GROUNDWATER

SUBCLASS G

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BUREAU OF INTEGRATED SCIENCE SERVICES
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PREFACE

This operator's study guide represents the results of an ambitious project. Operators of water supply facilities, regulators, educators and local officials, jointly prepared the objectives and exam questions for the Water Supply Groundwater Certification Exam.

The objectives in this study guide have been organized into four modules: (A) Principle, Structure and Function; (B) Operation and Maintenance; (C) Monitoring and Troubleshooting; and, (D) Safety And Calculations. The objectives are organized to correspond to the major concepts in each module.

This study guide was revised in 2006 to include new objectives relating to the EPA Disinfectants and Disinfection Byproducts (D/DBP) Rule. Objectives that were newly developed or revised to cover the D/DBP Rule are preceded by "***NEW***". Exam questions have been written to correspond to the concepts included in this study guide.

HOW TO USE THESE OBJECTIVES WITH REFERENCES

In preparation for the Water Supply Groundwater Exam, the operator should:

1. Read all the objectives and write down the answers to the objectives that readily come to mind.
2. Use the resources at the end of the objectives to look-up those answers you are not sure of.
3. Write down the answers found in the resources to those objectives you could not answer from memory.
4. Review all answered objectives until you can answer each from memory.

IT IS ADVISABLE THAT THE OPERATOR ATTEND SOME FORM OF FORMAL TRAINING IN THIS PROCESS BEFORE ATTEMPTING THE CERTIFICATION EXAM.

Choosing A Test Date

Before you choose a test date, consider the training opportunities available in your area. A listing of training opportunities and exam dates can be found in the annual DNR "Certified Operator," in the DNR's Operator Certification & Licensing Training Calendar on the DNR Web Site (<http://www.dnr.state.wi.us/org/es/science/opcert/training.htm>) or by contacting your DNR District operator certification coordinator.

GROUNDWATER

MODULE A: PRINCIPLE, STRUCTURE AND FUNCTION

CONCEPT: PRINCIPLES OF GROUNDWATER

1. Describe the movement of water through the hydrologic cycle.
2. Sketch a diagram of the hydrologic cycle and label the parts.
3. Define the following terms:
 - A. Water Table.
 - B. Permeability.
 - C. Infiltration.
 - D. Aquifer.
 - E. Impervious Layer.
 - F. Artesian Well.
 - G. Recharge Area.
 - H. Discharge Area.
4. State characteristics of a good aquifer and identify different types of formations which would serve as good aquifers.
5. List the factors which affect the depth at which groundwater is located.
6. Explain how water table levels are affected by seasonal changes.
7. List factors which affect the chemical and biological quality of groundwater.
8. Describe the health or aesthetic significance of the following elements and compounds:
 - A. Iron.
 - B. Manganese.
 - C. Hydrogen Sulfide.
 - D. Nitrate.
 - E. Fluoride.
 - F. Calcium.
 - G. Magnesium.
 - H. Dissolved Oxygen And Dissolved air.
 - I. Sodium.
 - **NEW**
 - J. Natural Organic Matter (NOM).
 - K. Bromide

9. State the principal purpose for the chlorination of water.
10. ****NEW**** Explain why the disinfection by-products trihalomethanes (TTHMs) and haloacetic acids (HAA5s) are a problem in drinking water.
11. ****NEW**** Describe how trihalomethanes (TTHMs) and haloacetic acids (HAA5s) are formed.

CONCEPT: STRUCTURE AND FUNCTION

12. List the six common types of wells, and identify which are suitable for municipal use.
13. Discuss sanitary hazards that should not be near a well.
14. Given a cross sectional sketch of a typical well, identify the air line, pressure gauge, air vent, static water level, pumping water level, drawdown, and cone of depression.
15. Describe the purpose of a well casing.
16. Explain why wells are grouted.
17. Explain the purpose of a well screen.
18. Given a diagram, label various features in a typical pumphouse.
19. Given a diagram of a vertical turbine pump, label the parts.
20. Describe the functions of the following parts of a vertical turbine pump:
 - A. Motor.
 - B. Pump Head.
 - C. Impeller.
 - D. Bowl Assembly.
 - E. Packing.
 - F. Shaft.
 - G. Thrust Bearing.
 - H. Strainer.
 - I. Spider.
21. Describe how a vertical turbine pump works.

22. From a sketch, identify the components of a direct acid (fluoride) feed system.
23. Discuss when a diluted acid (fluoride) feed system is used, and what additional equipment is needed for this type system.
24. From a sketch, identify and state the functions of the following components of a hypochlorination system:
- A. Hypochlorite Solution Container.
 - B. Suction Line, With Strainer.
 - C. Diaphragm Type Positive Displacement Pump.
 - D. Discharge Line.
 - E. Anti-Siphon Device.
 - F. Water Main Connection And Shut-Off Valve.
25. Given a sketch of a solution feed gas chlorination system, identify and state the function of the following components:
- A. Chlorine Gas Cylinder.
 - B. Yoke Unit.
 - C. Control Unit (Chlorinator).
 - D. Gas Vacuum Line.
 - E. Booster Pump and Piping.
 - F. Ejector.
 - G. Exhaust Fan.
26. Describe the operation of a solution-feed vacuum type gas chlorination system.

MODULE B: OPERATION AND MAINTENANCE

CONCEPT: OPERATION

27. Explain what a wellhead protection plan is, why it is important, and when it is required.
28. List the negative side effects of excessive groundwater use.
29. Site remedies that help eliminate undesirable side effects of excessive groundwater use.
30. Discuss the problems hard water can create for a utilities.
31. Explain why adjacent wells may have different water qualities.

32. Explain the effect well pumping can have on adjacent wells.
33. List the reasons for a rise or drop in the following:
- A. Static Water Level.
 - B. Pumping Water Level.
 - C. Specific Capacity.
34. Describe the methods available to determine water levels in wells.
35. State how often water levels should be determined.
36. Identify two forms of incrustations found on well screens.
37. Identify considerations to be taken before starting a vertical turbine pump.
38. Identify suitable injection points for the following chemicals:
- A. Sodium Hypochlorite.
 - B. Calcium Hypochlorite.
 - C. Gaseous Chlorine.
 - D. Hydrofluosilicic Acid.
 - E. Polyphosphate.
 - F. Sodium Hydroxide.
39. Describe how a chemical feed pump capacity can be controlled by:
- A. Length Of Stroke.
 - B. Number Of Strokes.
40. Define the following terms:
- A. Dosage.
 - B. Chlorine Demand.
 - C. Free Chlorine Residual.
 - D. Combined Chlorine Residual.
 - E. Total Chlorine Residual.
 - **NEW**
 - F. Maximum Residual Disinfectant Level.
41. Identify the various forms in which chlorine is available and the approximate percent available chlorine for each form.

42. Describe the physical properties (color, density, odor, etc.) of the following forms of chlorine:
- A. Gas.
 - B. Solid (Calcium Hypochlorite).
 - C. Liquid (Sodium Hypochlorite).
43. Discuss the effect drinking water containing the proper amount of fluoride has on teeth during the years of tooth development.
44. Describe the effect on teeth of drinking water containing fluoride greater than the maximum contaminant level (MCL) during the years of tooth development.
45. Discuss the purposes for adding polyphosphates to water.
46. Discuss problems with the use of polyphosphates.
47. Explain the purposes for adding sodium hydroxide.
48. ****NEW**** Identify control strategies for trihalomethanes (TTHMs) and haloacetic acids (HAA5s) acids.
49. ****NEW**** Discuss disinfection by-product precursors, precursor sources, and how to control them.
50. ****NEW**** Describe treatment process modifications capable of controlling trihalomethanes (TTHMs) and haloacetic acids (HAA5s) acids.
51. ****NEW**** Describe the disinfection by-product bromate, its precursor, how it forms, and how it can be controlled.

CONCEPT: MAINTENANCE

52. Describe good pump operational and maintenance procedures in relation to the following:
- A. Priming.
 - B. Packing.
 - C. Bearings.
 - D. Alignment.
53. Outline a preventive maintenance program for a positive displacement pump feeding hypochlorite.

- 54. Explain why lead or asbestos washers should never be reused.
- 55. Discuss the symptoms of old packing and cavitation in pumps.
- 56. Describe the methods of well rehabilitation.
- 57. Explain the types and importance of stand-by power availability at a treatment plant.
- 58. State how often stand-by power should be operated.

MODULE C: MONITORING AND TROUBLESHOOTING

CONCEPT: MONITORING

- 59. Differentiate between "primary" and "secondary" drinking water standards.
- 60. Identify secondary standards for the following:
 - A. Iron.
 - B. Manganese.
 - C. Hydrogen Sulfide.
- 61. State the monitoring requirements for the following:
 - A. Inorganic Chemicals (except Lead and Copper).
 - B. Lead and Copper.
 - C. Synthetic Organic Chemicals.
 - D. Disinfection/Disinfection By-Products.
 - E. Volatile Organic Compounds.
 - F. Radioactivity.
- 62. Identify the maximum contaminant levels (MCL's) for fluoride and nitrate.
- 63. Describe a good bacteriological sampling program.
- 64. Indicate how often bacteriological samples should be collected from a well if the water is chlorinated.
- 65. State the holding time for bacteriological samples.

66. Given hypothetical data, correctly complete a bacteriological report form.
67. Describe the procedure to follow when a bacteriological sample is deemed "unsafe".
68. Identify the laboratories where bacteriological samples may be analyzed.
69. List the circumstances where public notification is required.
70. State how often samples must be sent to the State Laboratory of Hygiene for fluoride analysis.
71. State how often an operator must test the chlorine residual in a groundwater-distribution system if chlorine is being added.
72. Specify the minimum free chlorine residual that must be maintained throughout the system if a groundwater source is required to be chlorinated.
73. ****NEW**** Explain the term maximum residual disinfectant level (MRDL) and list the MRDL for chlorine, chloramines and ozone.
74. Specify how often an operator must test for fluoride if fluoride is being added to the water.
75. Identify the sample container requirements used in collecting fluoride samples.
76. Identify values for the following:
 - A. Optimal Level For Fluoride.
 - B. Range Within Which Fluoride Should Be Maintained.
77. Define pH, and explain its importance to water supply operators.
78. List the acidic, neutral, and basic values for pH.
79. Identify methods to control corrosive water.
80. Discuss the various methods used to determine the stability of water with respect to calcium carbonate saturation.

81. Describe the calculations involved in using the Langelier Index and the Calcium Carbonate Solubility Curve in determining corrosive or depositing properties of a particular water.
82. ****NEW**** Identify where samples are collected for trihalomethanes (TTHMs) and haloacetic acids (HAA5s) analysis and list the MCLs.

CONCEPT: TROUBLESHOOTING

83. Explain remedial measures for drops in the static water level, pumping water level, and specific capacity.
84. List possible causes and remedies for the following pump symptoms:
- A. Short Bearing Life.
 - B. Cavitation.
 - C. Short Packing Life.
 - D. Vibrating Pump.
 - E. Pump Loses Prime.
 - F. Reduced Rate Of Discharge.
 - G. Pumps Will Not Start.
85. Describe the possible reasons for a well pump breaking suction.

MODULE D: SAFETY AND CALCULATIONS

CONCEPT: SAFETY

86. Describe the safety considerations when preparing a solution of hydrofluosilicic acid.
87. List the rules concerning chlorine storage.
88. Describe a method of detecting chlorine gas leaks.

CONCEPT: CALCULATIONS

89. Using a pressure gauge that reads in feet, determine the static water level, pumping water level, and drawdown in a well.

90. Given the static water level, pumping water level and pumping rate, calculate the specific capacity of a well.
91. Given water meter readings from the well house meter, estimate the daily pumpage or given pumping rate (calculate total gallons).
92. Given a graph of water pumpage versus volume of chemical used, determine the calculated dosages when volume of chemical and pumping rates are given.

GROUNDWATER RESOURCES

1. **SMALL WATER SYSTEM OPERATION AND MAINTENANCE**. 1st Edition (1990). Kenneth D. Kerri. California State University, 6000 J Street, Sacramento, CA 95819-6025. Phone (916) 278-6142.
 2. **STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER**. 17th Edition (1989), 18th Edition (1992). Joint Publication of: American Public Health Association; American Water Works Association; and, Water Environment Federation (Old WPCF). Publication Office: American Public Health Association, 1015 Fifteenth Street NW, Washington, DC 20005.
 3. **WISCONSIN ADMINISTRATIVE CODE NR 809 SAFE DRINKING WATER**. Wisconsin Revisor of Statutes Bureau
 4. **WISCONSIN ADMINISTRATIVE CODE NR 811 REQUIREMENTS FOR THE OPERATION AND DESIGN OF COMMUNITY WATER SYSTEMS**. Wisconsin Revisor of Statutes Bureau.
- Wisconsin Administrative Codes are available electronically at <http://www.legis.state.wi.us/rsb/code.htm>. To purchase printed code books contact the Wisconsin Department of Administration, Document Sales and Distribution Section at 608-266-3358.
5. **WELLHEAD PROTECTION: AN OUNCE OF PREVENTION**. PUBL-WR-303 92 (1992) Department of Natural Resources, Bureau of Water Supply, P.O. Box 7921, Madison, WI 53707.
 6. ****NEW** Complying With the Stage 1 Disinfectants and Disinfection Byproducts Rule: Basic Guide**. US EPA (March 2006) EPA No. 816-B-05-004.

Supplement A to the above publication covers water systems that use chlorine dioxide or ozone as a disinfectant. US EPA (March 2006) EPA No. 816-B-05-005.

Supplement B to the above publication covers water systems that utilize a surface water source. US EPA (March 2006) EPA No. 816-B-05-006.

EPA publications can be downloaded from EPA's Safe Drinking Water Web site at www.epa.gov/safewater (search by publication number). You can also call the Safe Drinking Water Hotline at 1-800-426-4791 to request the documents.

THE FOLLOWING ADDITIONAL RESOURCES CAN BE OBTAINED FROM:

AMERICAN WATER WORKS ASSOCIATION
MEMBER SERVICE DEPARTMENT
6666 W. QUINCY AVENUE
DENVER, CO 80235
(303) 794-7711

1-800-92-ORDER (CHARGE CARD CUSTOMERS OR AWWA MEMBERS ONLY)

7. BASIC MANAGEMENT PRINCIPLES FOR SMALL WATER SYSTEMS. AWWA No. 20222 (1982).
8. BEFORE THE WELL RUNS DRY - VOLUMES I AND II. VOLUME I, AWWA No. 20224 (1984). VOLUME II, AWWA No. 20225 (1984).
9. CORROSION CONTROL FOR OPERATORS. AWWA No. 20232 (1986).
10. CROSS-CONNECTION AND BACKFLOW PREVENTION. Gustave J. Angele. AWWA No. 20106 (1974).
11. DISINFECTION BY-PRODUCTS: CURRENT PERSPECTIVES. AWWA No. 20032 (1989).
12. IMPROVING WELL AND PUMP EFFICIENCY. Otto J. Helweg, Verne H. Scott, and Joseph C. Scalmanini. AWWA No. 20167 (1983).
13. MAINTENANCE MANAGEMENT. James K. Jordan. AWWA No. 20252 (1990).
14. NEW DIMENSIONS IN SAFE DRINKING WATER-SECOND EDITION. AWWA No. 20235 (1988).
15. PLAIN TALK ABOUT DRINKING WATER. James M. Symons. AWWA No. 70076 (1991).
16. PUBLIC INFORMATION - HOW TO BUILD A SUCCESSFUL PUBLIC INFORMATION/PUBLIC RELATIONS PROGRAM. AWWA No. 20242 (1989).
17. SAFE DRINKING WATER ACT SERIES:
PUBLIC NOTIFICATION. AWWA No. 70056 (1990)
TOTAL COLIFORM RULE. AWWA No. 70057 (1990)
VOC'S AND UNREGULATED CONTAMINANTS. AWWA No. 70058 (1990)
LEAD AND COPPER. AWWA No. 70073 (1991)
PHASE II: VOC'S, IOC'S, AND SOC'S. AWWA No. 70074 (1991)
18. TREATMENT TECHNIQUES FOR CONTROLLING TRIHALOMETHANE IN DRINKING WATER. AWWA, No. 20221 (1982).
19. WATER CONSERVATION. William O. Maddaus. AWWA No. 20238 (1987)
20. WATER QUALITY AND TREATMENT-FOURTH EDITION. AWWA No. 10053 (1990).